

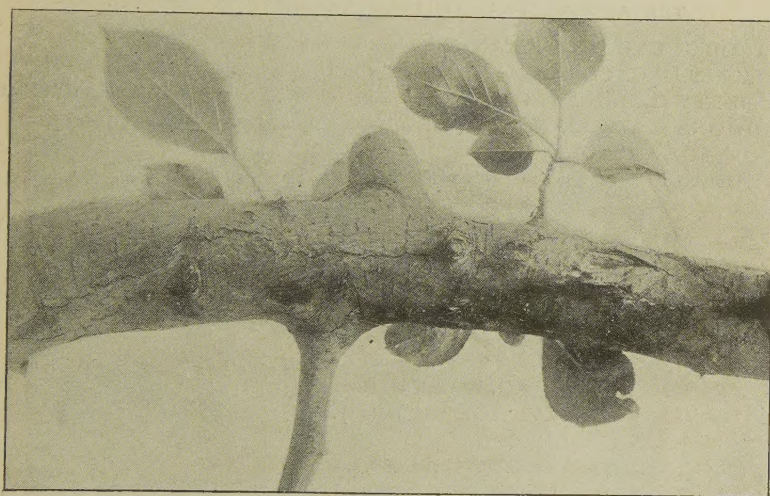
Flora W. Patterson

FEBRUARY, 1906.

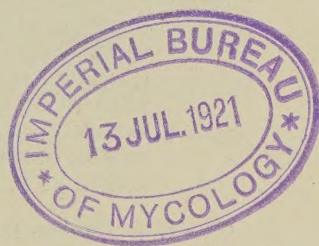
BULLETIN 236

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Department of Botany (Extension Work)

THE BLIGHT CANKER OF APPLE-
TREES.



By H. H. WHETZEL



ITHACA, N. Y.
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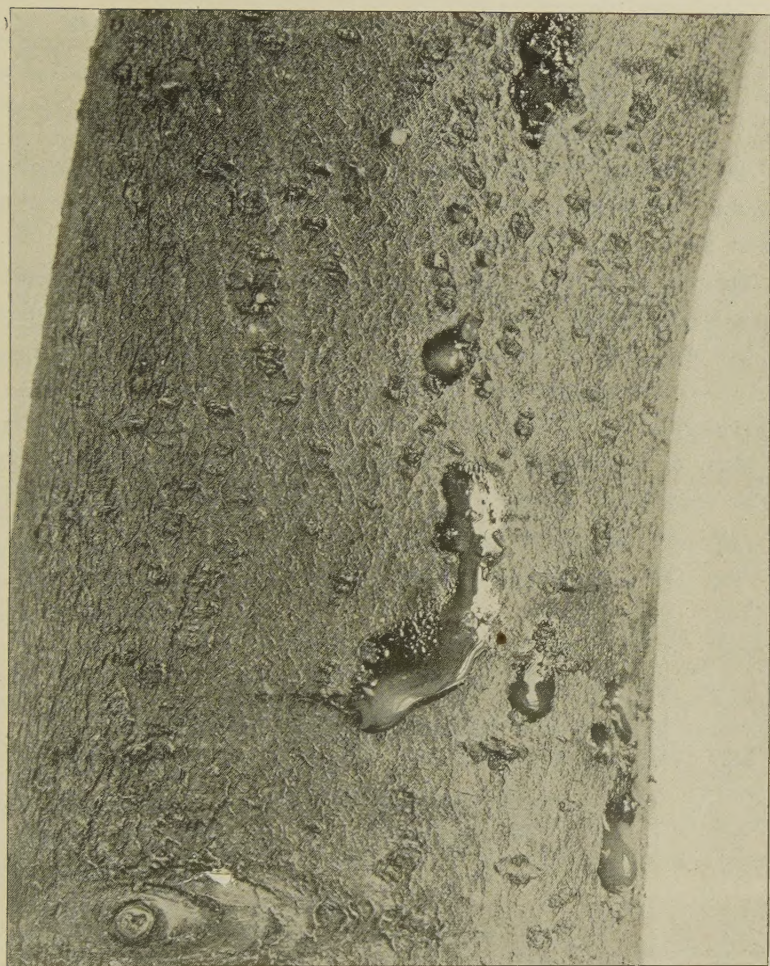


FIG. 51.—Active canker showing the exuding milky drops. This sticky sap is made up almost entirely of the blight bacteria.

COLLEGE OF AGRICULTURE CORNELL UNIVERSITY.

ITHACA, N. Y.

HON. CHAS. A. WIETING,

Commissioner of Agriculture.

Sir :—I hereby transmit a report of the investigations of the College of Agriculture on blight cankers that are coming to be very destructive of apple trees in many parts of the State.

This canker is found to be due to the same organism (a bacterium) that causes the blight of the pear. It is superinduced by over-rapid growth of the tree, and the points of inoculation are water-sprouts, wounds, and possibly the flowers. There is no cure, but further spread of the cankered areas may be prevented by careful treatment of the wounds as explained on page 119.

Many of the Bulletins issued by this institution relate to the apple industry in New York State, and the following numbers are devoted exclusively to it :

- 48. Spraying Apple Orchards.
- 84. The Recent Apple Failures.
- 116. Dwarf Apples.
- 207. Pink Rot an Attendant of Apple Scab.
- 214. The Ribbed Cocoon-Maker of the Apple.
- 226. An Apple Orchard Survey of Wayne County, New York.
- 229. An Apple Orchard Survey of Orleans County, New York.

Respectfully submitted,

L. H. BAILEY,

Director.

THE BLIGHT CANKER OF APPLE TREES.

I. CANKERS AND WHAT THEY ARE.

During recent years several kinds of cankers, occurring especially upon apple trees, have been described and figured in bulletins from different experiment stations in this country. A canker of fruit trees has long been known in Europe, due to the attacks of a fungus, *Nectria ditissima*.^{22*} This disease has also been reported from America.¹⁵ By careful inoculation experiments, these various cankers have been shown to be due to different species of either fungi or bacteria. Some of these canker diseases are peculiar to certain regions only. Others are more cosmopolitan and are likely to be found wherever apple trees are grown.

Notwithstanding the fact that these injuries to the bark of living trees have been, in the large majority of cases, absolutely proved to be due to the growth of parasitic fungi or bacteria, growers very generally even at the present time attribute them to "sun scald" or "winter injury." Lack of knowledge of the nature of fungous and bacterial growth, together with the ease with which responsibility may be shifted upon the weather, have made this opinion the common and natural one. Not only have experiment station workers shown that these injuries are usually due to the attacks of living organisms rather than to the results of unfavorable weather conditions, but they have demonstrated that the different forms of these cankers are due to distinctly different organisms.

The term "canker," then, has come to be a very general one and is applied to diseases which cause the death of definite areas of bark on the limbs and bodies of trees. The diseased area may be smooth and sunken or enlarged and roughened, depending on the nature of the organism causing it. Most "cankers," as the term is understood at the present time, are caused by the attacks of some parasitic plant, either a fungus or bacterium.

The following distinct canker diseases of apple trees have been described. Those marked with a † are known to occur in this State :

† European canker¹⁵ (*Nectria ditissima* Tul.).

† New York Apple Tree Canker¹⁶ (*Sphaeropsis malorum* Pk.).

Black Spot Canker¹⁴ (*Gloeosporium malicorticis* Cordley). First described by Cordley in 1900 as "Apple Tree Anthracnose"¹⁰. Also referred to as Pacific coast canker.

Illinois Apple Tree Canker¹² (*Nummularia discreta* Tul.).

Bitter Rot Canker⁸ (*Glomerella rufomaculans* (Berk.) Spal. & v. Schr.).

† Blight Canker of apple trees²⁰ (*Bacillus amylovorus* (Burr.) de Toni.).

It is to the last of these, the Blight Canker, that this bulletin is espec-

* These numbers refer to the bibliography at the end of this bulletin.

ially devoted. Although this particular kind of cankered spots on apple trees was probably first observed by horticultural writers as early as 1780¹¹ and has been repeatedly referred to in horticultural writings since that time, its true nature does not seem to have been suspected until 1880. In that year Profes-

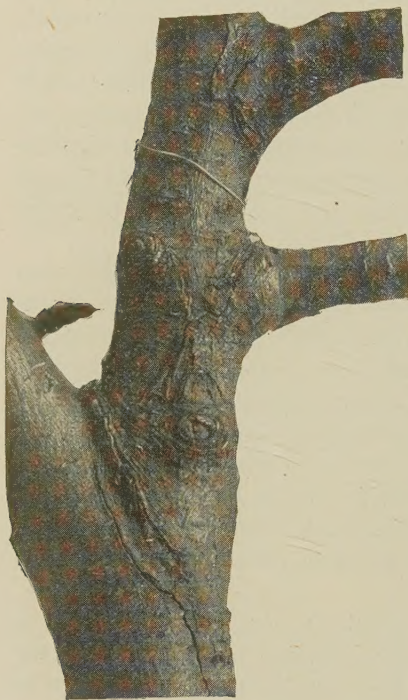


FIG. 49.—*Typical blight canker on main limb of young tree.*

sor T. J. Burrill, of the Illinois State Experiment Station, while working on the fire blight of pears and apples, came to the conclusion that the so-called "sun scald" spots on the bodies and larger limbs of apple trees are due to the same cause. At a meeting of the Illinois State Horticultural Society in 1881¹⁵ in answer to a query regarding the nature of "sun scald", he said: "The sun scald on apple tree is the same as pear blight." Similar statements of Professor Burrill upon the same subject are recorded in other places.⁶ Upon what experimental evidence, if any, this and other statements⁷ were based I have so far failed to discover. A number of writers² since that time have referred to these cankered patches as "body blight" due to attacks of *Bacillus amylovorus*,¹⁹ but none seem to have actually produced the cankers by the introduction of the bacteria into the bark of healthy trees.¹⁷

2. THE DISTINGUISHING CHARACTERS AND APPEARANCE OF THE CANKER.

The blight canker (Fig 49), while it may occur on trees of almost any age, is most destructive on young trees just coming into bearing, trees from 8 to 15 years old. In some sections of this State, notably the Upper Hudson River Valley, at least 95 per cent of the trees of this age show canker on limbs or body. A very large percentage of the affected trees are dead and the remainder are fast succumbing. Very noticeable throughout this section also are the large number of trees with cankers in the crotches (Fig. 50) where the main limbs arise from the body. In this same region a good sized orchard, set out about three or four years ago, was observed to have suffered severely evidently from this same disease. In this orchard the disease usually involved, the greater part of the tree, often killing it to the ground. The

cankers have also been observed in the upper crotches and on the sides of the large limbs in old trees. Spreading from these points of infection, the disease may gradually involve the entire limb, causing its death. Old trees weakened by age and neglect may suffer seriously from such attacks and the dead limbs protruding here and there from the green foliage in old orchards are often to be attributed to the ravages of this canker.



FIG. 50.—*Baldwin tree killed by attack of blight canker in the crotches of the main limbs.*

In young trees with smooth bark the cankers are easily detected, even in their first stages. They appear as discolored and somewhat sunken areas, the margin along the advancing front being usually slightly raised or blistered. The tissue in actively spreading cankers is of a darker green than the healthy bark and is very watery or sappy. On damp cloudy days drops of a milky, sticky fluid (Fig. 51) exude from the cankered tissues through the lenticels or pores in the bark. After a short time the diseased tissue begins to turn brown and dry out. Unless in a very active state of progress the margins are very distinct, marked by a crack where, in

As already pointed out, it is on young trees that the canker is most dangerous, for unless promptly attended to the disease is almost certain to result in the death of the entire tree.



FIG. 52.—*Typical canker showing the crack about the margin where the diseased bark has dried away from the healthy tissue.*

After a short time the diseased tissue begins to turn brown and dry out. Unless in a very active state of progress the margins are very distinct, marked by a crack where, in

drying, the diseased tissue has separated from the healthy bark (Fig.

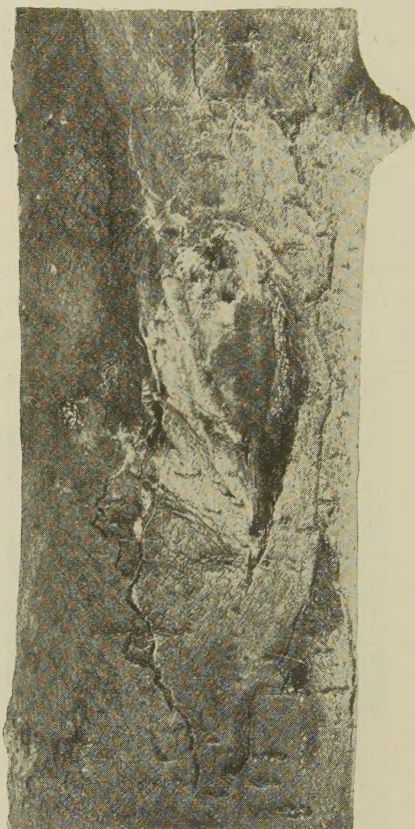


FIG 53.—*Concentric cracks in the cankered area, indicating two periods of activity during the season due to abrupt changes in the weather conditions.*

52). The older cankers are brown, somewhat darker than the healthy bark. They are distinctly sunken. The surface is smooth, never checked or roughened or beset with pustules or pimples, except in the old cankers, where, after a time, rot fungi gain entrance and, thriving in the already dead tissues, produce their fruit bodies on the surface. The progress of the spreading canker depends largely on the continuation of favorable weather conditions, which seem to be a humid atmosphere and cloudy days. With the return of bright sunny weather, the active spread of the canker is checked abruptly, often to be resumed again with the return of favorable conditions. This checking and renewing of activity sometimes result in large cankers with concentrically arranged cracks within the cankered area (Fig. 53). This renewal of activity may take place during the same season or the canker may partially heal over to spread anew the following year (Fig. 54). A large percentage of the cankers are active during but one season. There are always some, however, in which the disease is perennial, living

through the winter to become active again the following spring, spreading and enlarging the original limits of the cankered area (Fig. 55). The diseased bark is usually killed to the wood, to which it clings tenaciously the first season. It gradually decays, however, and falls out, leaving the wood bare and exposed (Fig. 54). In small cankers the cone of diseased bark may be quickly forced out by the rapidly formed calluses, which heal and close the canker wound (Fig. 56). In some cases the canker is superficial, never reaching the cambium except, perhaps, in a limited area at the point of infection. Such wounds heal quickly beneath the dead bark, which clings to the tree as a sort of scab (Fig. 57).

The cankers vary in size from half an inch in diameter to as much as a foot or more in length and several inches across. On healthy vigorous trees they are small and more or less circular in outline. They form funnel-shaped wounds with the small end toward the wood. These I have designated as "pit cankers" (Fig. 58). Often the dead bark remains as a sort of lid to the pit (Fig. 56), but it is easily removed with the finger or a knife blade. I have seen young trees with limbs and body literally covered with these pit cankers in all stages of healing over. Aside from afford-



FIG. 54.—Cankers in body of tree resulting from the renewal of activity season after season. Observe that these started from small pit cankers which partially healed each season. The disease the following season destroyed all the bark growth, leaving only the little bit of wood formed in the callus. This still persists.



FIG. 55.—Canker spreading the second season, destroying callus of last season and enlarging area of cankered surface.

ing an entrance to rot fungi, such cankers, unless they enlarge, do not seriously affect the health of the tree. In many cases these pit cankers do not heal properly or at all, and the disease, spreading the same or the following season, forms the large and dangerous "limb" or "body cankers" (Fig. 59).

"Crotch cankers" (Fig. 60) usually appear in the crotches where the main limbs arise from the body, but may also appear in the secondary crotches



FIG. 57.—The wound healing beneath the cankered bark, which still clings to the tree as a sort of scab. This canker was more or less superficial.



FIG. 56.—Pit canker. Rapidly forming callus closing the wound and forcing out the diseased bark.

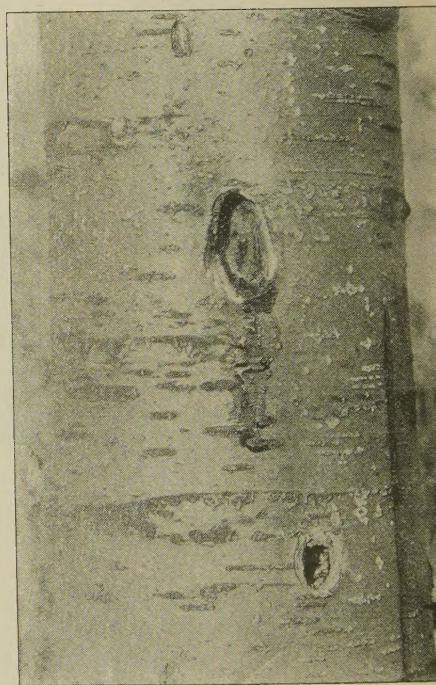


FIG. 58.—Typical pit cankers in the body of tree from which the diseased bark has dropped out. The upper one is exuding sap,—“bleeding.”

well up in the tree. In general characters they are similar to the limb and body cankers. Owing to their peculiar position, water is retained more readily in the dead bark, thus affording the very best conditions for the entrance and growth of rot fungi. These find easier access to the heart wood at the crotch than on the limbs. It was observed that these crotch cankers heal much less readily and successfully than do the limb and body cankers. Crotch cankers, unless promptly attended to, mean the almost certain destruction of the trees.

The large cankers at the bases of young trees (Fig. 61), frequently referred to by growers as "collar rot,"



FIG. 59.—Large body canker resulting from successive seasonal attacks of the disease. Originated at the pruned stub.

are in many cases very probably due to the same cause as that of the cankers on the upper parts of the tree. The well known "collar rot" of King trees may also be due to the same or a similar organism.



FIG. 60.—Typical crotch canker. Dead bark has been removed. Callus forming about the margin.

How this Canker Differs from the Well Known New York Apple Tree Canker.

The New York apple tree canker (Fig. 62) described by Paddock¹⁶ in Bulletins No. 163 and No. 185 of the New York (Geneva) State Experiment Station, is very abundant and destructive in many orchards of the State. It is caused by a fungus and is in most respects very different from the blight canker with which, nevertheless, it is frequently confused. The chief differences between the two are set forth in the following parallel columns:

NEW YORK APPLE TREE CANKER.	BLIGHT CANKER.
Caused by a <i>fungus</i> .	Caused by <i>bacteria</i> .
Usually found on the main limbs of <i>old</i> trees.	Occurring most frequently on the body and limbs of <i>young</i> trees just coming into bearing.
Diseased portion more or less <i>swollen</i> , <i>cracked</i> and <i>roughened</i> . (Fig. 62.)	Diseased area <i>sunken</i> and <i>smooth</i> not cracked and checked. (Fig. 53.)
Cankered surface <i>black</i> .	Cankered surface <i>brown</i> .
Covered with <i>minute black pimples</i> —the fruit bodies of the fungus often not so evident in old cankers. (Fig. 62).	<i>Not</i> showing any <i>pimples</i> or <i>fungus fruit bodies</i> , except in old cankers that have been invaded by saprophytic forms.
Freshly cankered tissue <i>dry</i> .	Freshly cankered tissue <i>watery</i> .
Cankers <i>perennial</i> , <i>i. e.</i> , living over and spreading from year to year.	<i>A large per cent</i> of the cankers <i>active but one season</i> .

3. HOW THE DISEASE AFFECTS THE TREE.

The effect of the canker on the tree is to lower its vitality to a greater or less degree by cutting off the food supply to the roots, and thus indirectly reducing the flow of sap to the branches and leaves. In other words, it acts the same as partial or complete "girdling." The "collar rot" and "crotch cankers" seem to be the most fatal to the tree. The effects of the canker are first evidenced in the foliage. If there is a large body canker, the entire tree may show the effects of the trouble. More often the first symptom noted by the grower is the peculiar appearance of the foliage on one or more of the limbs. Either these branches fail to leaf out at all in the spring, or if they do the leaves never fully expand but remain undersized and curled or inrolled. They never take on the dark green color of healthy foliage, but remain pale and gray. Growers often refer to such trees as having "mouse ear" leaves. As the season advances and the cankers spread, the leaves often die and dry up on the branches (Fig. 63). Sometimes badly affected trees will pull through until autumn or even live for two or three seasons. Such trees have scanty foliage, blossom profusely and frequently set a heavy crop of fruit. This fruit falls prematurely or is small and inferior in quality. Fig.

64 shows a large body canker at the base of one of the main limbs on an old tree. The canker had nearly girdled the limb. This spring the branch was loaded with blossoms to the exclusion of foliage, while the other limbs of the tree bore a normal quantity of flowers and leaves. Such affected limbs and trees, as if in anticipation of their approaching death, seem to devote their expiring energy in one grand and final effort to reproduce themselves.

As I have already pointed out, small cankers may not of themselves seriously affect the health of the trees. When the trees are strong and vigorous they frequently succeed in promptly healing the wounds. The dead bark of the canker, however, makes, an excellent infection court for the entrance into the tree of "heart rot" and decay-inducing fungi. Moisture, so necessary to the germination and growth of the spores of fungi, is retained for a considerable time in the dead tissue. This is more especially true of crotch cankers. No doubt these rot fungi are often to blame for the final death of the tree. The heartwood of badly affected limbs and trees is commonly found to be soft and rotted, with only a thin rim of sound sapwood surrounding it.



FIG. 61.—Large body canker near base of tree, often referred to as "collar rot." The tree has made repeated attempts to heal this wound.

4. THE CAUSE OF THE CANKER.



FIG. 62.—Typical New York apple tree canker, caused by the fungus *Sphaeropsis malorum*. Comparatively young canker. Observe the little pimples covering the diseased bark,—the spore-cases of the fungus.

A microscopic examination of the viscid milky drops that exude from freshly cankered surfaces (Fig. 51) on moist cloudy days shows them to be composed almost entirely of minute rod-shaped bacteria. The diseased tissue within the bark is also found to be alive with these minute plants. By their rapid growth and multiplication within the cells of the bark, they cause its death. They are not carried along in the sap but slowly work their way from cell to cell. When the canker dries down they die and disappear, so that examination of the tissue of old cankers does not show them. That they are the direct cause of the disease was proved in the following way: Bacteria from the cankered tissue were introduced into the bark on the body of a healthy apple tree and also into the bark of a healthy pear tree, with the result that typical cankers appeared in both cases. (Figs. 65 and 66.) Blossoms and growing twigs of both pear and apples were also inoculated with bacteria from this same canker. These nearly all developed good cases of blight (Figs. 67, 68 and 69) in about ten days, while twigs and blossoms punctured with a sterile nee-

dle gave no infection. This last experiment was twice repeated during the summer with pure cultures of the bacteria from the apple tree canker. The blight resulted in practically every case. Young fruits of both the pear and apple were also inoculated and gave well developed cases of the disease.



FIG. 63.—*Badly cankered trees showing the dead leaves clinging to the branches.*

(Fig 70.) By a comparative study in various culture media of the bacteria from cankers, twigs and fruits of both pear and apple (Fig 71) secured from different orchards about Ithaca, the organism of the canker was shown to be identical with that of the well known "fire blight" of the pear and "twig blight" of the apple.

5. HOW TREES BECOME INFECTED.

Aside from the nature of the organism causing the malady, perhaps the most important question in taking up an investigation of a given plant disease is that of how the parasite gains entrance into the host. The answer to this question is the prime requisite for intelligent effort in combating the disease.



FIG. 64.—*Large body canker on the side of an old tree.*

Much of my attention while in the field during the past season has been directed to a solution of this problem. Only those ways of infection which personal observation has discovered are here recorded. No doubt the bacteria gain entrance to the bark in still other ways than those I have observed.

The bacteria frequently get into the bark of the limbs and body by way of short spurs and watersprouts. (Fig. 72.) Early in my investigations I came to this conclusion. The opinion was fully confirmed later in the season. Twig blight became very prevalent during July and August, especially in the region about Ithaca. It was then an easy matter to find blighted spurs and watersprouts with active cankers about their bases. (Fig. 73). When

these watersprouts grew out from the trunks, as is often the case in young trees, typical body cankers were formed. (Fig. 74). The infection of the sprout itself is generally attributed to the work of insects, which after visiting freshly cankered sprouts or blighted twigs introduce the bacteria into the succulent tissues of the rapidly growing healthy shoots. The blighted watersprout soon dries up and falls away, leaving often a very indefinite scar in the cankered area so that the following season it is usually impossible to tell with certainty the manner of infection. Observation on a large number of trees during the past season, convinces me that the blighting of adventitious

shoots on trunk and limb is responsible for most of the cankers in such locations. A number of cankers were produced in this way by artificial inoculation. (Fig. 68.)

Another source of infection was found to be the pruning knife. Along one side of an orchard of some 350 trees which was under observation throughout the season, it was early noticed that the pruned stubs of 1904 especially, showed collars of dead bark often two or three inches in width. (Fig. 75.) Instead of forming a callus and healing over the wound, as would normally occur, the tissue had died and shriveled up but still clung to the stub. In

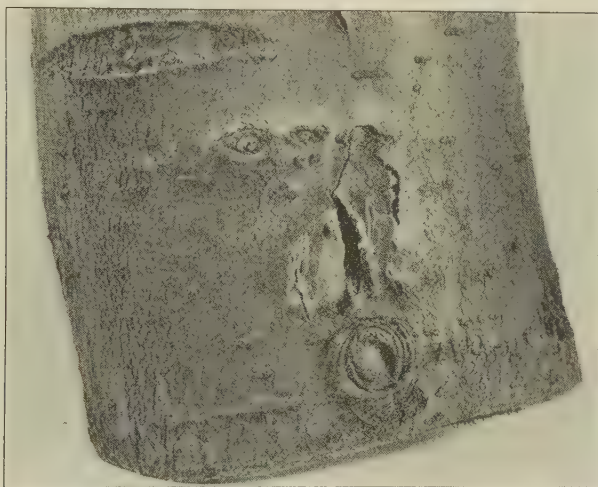


FIG. 65.—Canker near base of apple tree, resulting from artificial inoculation with bacteria direct from canker on another apple tree.

most cases the bacteria which had caused the death of the bark had died out the first season. In a few instances, however, the canker was observed to be active early in the spring, extending down the side of the adjoining limb. (Fig. 76.) Two badly diseased trees on this side of the orchard seem to have been the source of infection. Owing to their diseased condition, they had been severely pruned the previous season and very probably the knife or saw had carried the bacteria to the healthy trees. Flies which were observed constantly to follow the pruner to suck up exuding sap, may have been the direct agent in many cases in transferring the bacteria. The knife itself may convey the disease, as is shown by the following incident: While making inoculations into the body of an apple tree on the Station grounds, I had occasion to remove from near the base, a large sprout of several years'



FIG. 66.—Canker on pear tree resulting from inoculation with bacteria from active canker on apple tree.



FIG. 67.—Growing twig of apple blighted by artificial inoculation with bacteria from active canker on limb of apple tree.



FIG. 68.—Blossom and spur blight of apple resulting from artificial inoculation with bacteria from canker on limb of apple tree. Note the small cankers that have formed about the base of the spurs.

growth. This I did with my knife which I had but shortly before used to cut bark from a fresh canker. A typical canker soon developed about this pruned stub. (Fig. 77.)

Of a similar nature are infections that occur through wounds or bruises on the limbs and bodies of trees. These wounds, commonly results of "barking," may be made by careless workmen when plowing or working about the trees or from the gnawing of animals; one of the worst animals in New York is the woodchuck. A large percentage of such wounds heal over eventually, but frequently through the agency of insects or other means these wounds serve as infection courts for the canker bacillus. An interesting case of



FIG. 69—*Actively growing pear twigs blighted by artificial inoculation with bacteria from canker on limb of apple tree.*

wound infection came under my observation last season. In cutting a cankered branch I accidentally "barked" a healthy limb with the cut end of the diseased branch. The tree was not again visited until some weeks later, when a large and actively spreading canker was found to have developed about the abrasion (see front cover). The bacteria were found in abundance in the diseased tissue and pure cultures were secured.

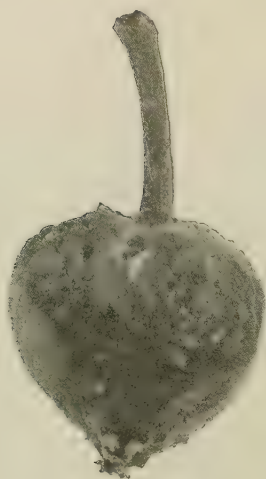


FIG. 70. — Half grown apple inoculated with pure culture of bacteria from canker on limb of apple tree. Note milky drops exuding from diseased tissue.

The wounds or punctures of insects seem to be directly responsible for some of the infections. Sometimes cankers on the bodies of trees cannot be attributed to infection through blighted shoots. In some cases these cankers have been traced directly to the wounds made by insects. Fig. 78 shows a hole made by a borer at the base of a tree and surrounding it is a well developed canker. It is very probable that many of the cankers at the base of young trees originate in wounds made by borers. The bacteria are probably carried to these wounds by flies or other insects which visit these places to feed on the exuding sap and excrement. The infecting agents in the case of crotch cankers have not as yet been definitely determined. It seems likely that insects again are here responsible. I have found them repeatedly hiding in the crevices of



FIG. 71. — Naturally infected apple. Infection probably took place in the spur at the base of the stem, through which it worked its way to the young fruit.

the dead bark that accumulates in the crotches, and one species seems to feed to some extent on the living tissue in such places. I have also observed this same species feeding on the exuding sap of cankered limbs and stubs. That it may carry the bacteria to the crotches seems obvious. Besides this, many of the crotches are of such a form that they readily retain moisture and thus afford the best of conditions for bacterial growth.



FIG. 72.— *Cankers on limbs of apple which originated through blighted spurs.*

At a general deduction, then, it may be stated that infection occurs only through a wound of some sort. Moreover, the infection court must be of such a nature that it will not dry out quickly. An abundance of moisture is known to be necessary to the rapid growth and development of the blight organism. This was repeatedly demonstrated in the large number of pure cultures which I had under observation during the summer. The growth was most abundant and vigorous in liquid media. This peculiarity accounts for the ease with which growing shoots are infected. When the diseased tissue of an active canker was at once cut out and the wound exposed to the drying heat of the sun without any other treatment, the canker ceased to spread and the place healed rapidly.

6. TREATMENT THAT PROMISES BEST RESULTS.

Although the work of the past season has been devoted largely to a study of the various manifestations of the disease, its cause and distribution, still some attention has been given to the means of combating it. Through the kindness of several men, in different parts of the State, I have had the opportunity of carrying on some experiments along this line on their trees. PREVENTION rather than CURE is one of the axioms of plant pathology. In most cases the curing of a diseased plant is impossible, or its value does not warrant the effort required to save it. However, in the case of trees just

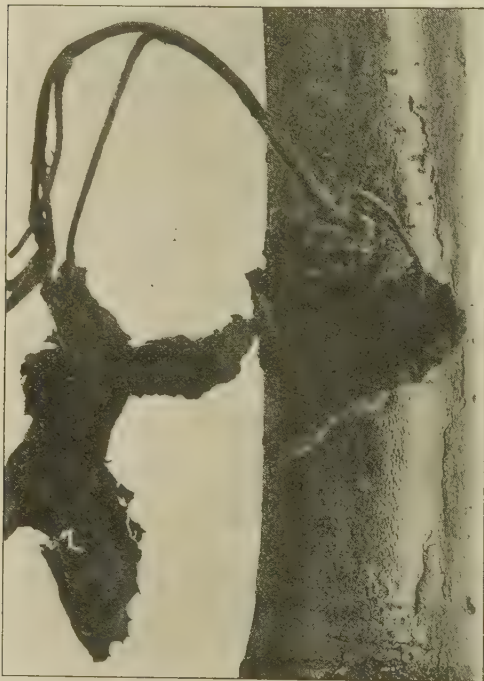


FIG. 73.—Recently blighted shoot on limb of Greening apple tree with well marked active canker about its base.

coming into bearing it seems that, if possible, some means of saving them should be worked out. Several things were accordingly tried, but the one that so far gives most promise of definite results is to *cut out the cankers* (Fig. 76). With a sharp knife remove all the diseased tissue (Fig. 79), swab out the wound with a weak solution of corrosive sublimate (one tablet to one pint of water), or with a three per cent solution of copper sulfate (1 ounce to 2 gallons water), and when dry, paint over thoroughly with some heavy lead paint. This should be done early in the season, as soon as the cankers are discovered, for two reasons: 1st, the spreading of the canker and its consequent damage to the tree is checked; 2d, the wound is thus given a long period in

which to heal. The painting should be repeated again toward the close of the season and again the next year, or until the wound has completely healed. This prevents a second infection or the entrance of rot fungi. A twice-monthly inspection of every tree should be made and all cankers carefully cut out and treated as soon as they appear. Cankered trees so treated early in the spring of 1905 have formed good calluses and are fast healing the wounds (Figs. 80, and 81).



FIG. 74.—*Typical body canker in its first stage. Resulting from injection through blighted watersprouts.*

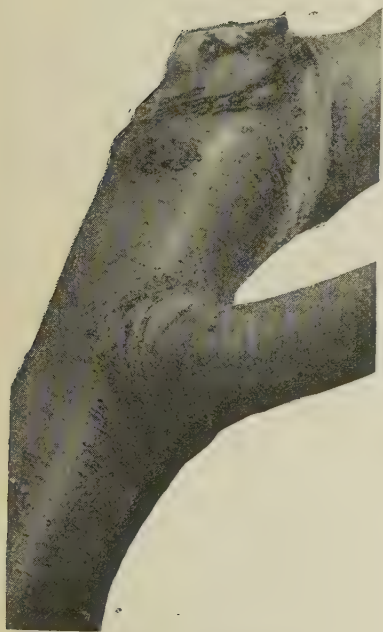


FIG. 75.—*Pruned stub canker. Infected at time of pruning, probably by the saw. Note the collar of dead bark.*



FIG. 76.—*Pruned stub canker. The bacteria did not die the first season, but continued throughout the winter slowly to work down the side of the limb. The diseased bark has all been cut away preparatory to treating and painting the wound.*

7. PREVENTIVE MEASURES.

It is scarcely necessary to point out that every precaution should be taken to prevent bruises or injuries of any sort, since these make excellent infection courts for the entrance of the bacteria.

All dead limbs and trees should be promptly removed from the orchard and BURNED. Old pear trees in the neighborhood of young apple orchards are often a constant source of infection, and, unless kept absolutely free of the blight, should be removed. A neighbor careless in respect to blight in his pear trees provides a dangerous source of infection.

Cut out and burn every trace of twig blight from both pear and apple trees as soon as it is detected.

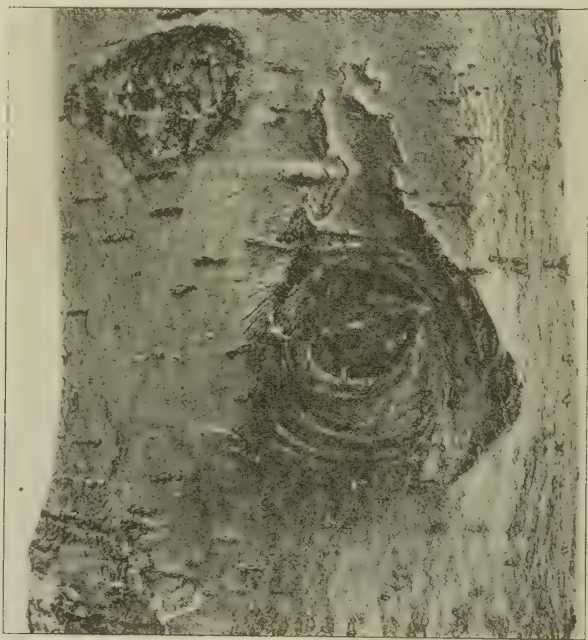


FIG. 77.—*Pruned stub canker resulting from cutting away a watersprout with a knife used shortly before to cut out an active canker and not disinfected.*

When pruning, treat all cut surfaces with the corrosive sublimate or copper sulfate solution and keep them painted until healed. Treat all accidental wounds in the same way.

Keep the body and main limbs of the tree free of watersprouts throughout the summer.

In planting, choose trees with open or spreading crotches.

Avoid excessive fertilizing with nitrogenous manures. Apply some form of phosphoric acid to ripen new growths.

The planting of varieties known to be more or less resistant to this disease is to be recommended. The Wolf River and Talman Sweet appear to be of this sort, while Baldwin and Ben Davis suffer most severely. Desirable non-resistant varieties may be top grafted on resistant stocks.

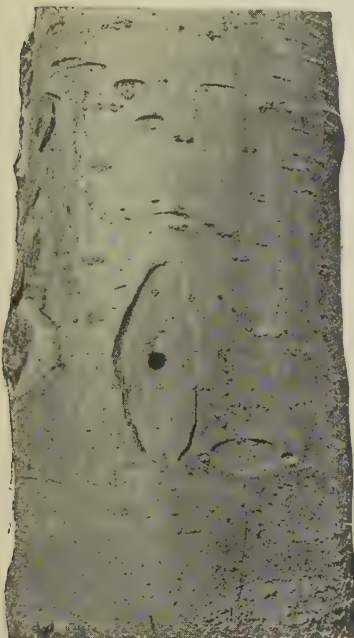


FIG. 78. Canker formed about the mouth of the burrow of a borer near base of an apple tree.

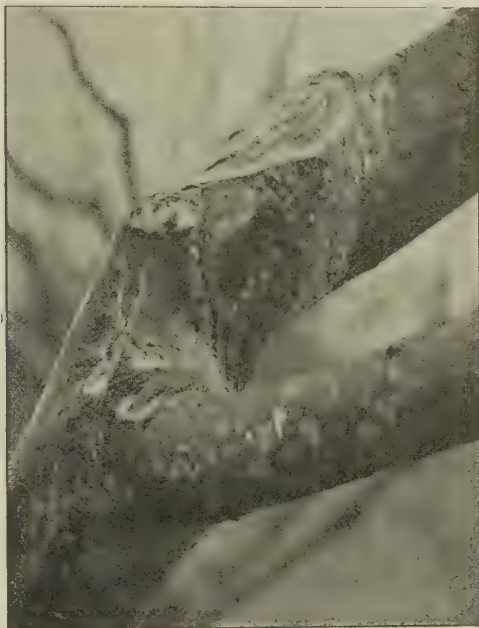


FIG. 79.—Pruned stub canker, with diseased bark and stub removed, treated with corrosive sublimate and painted over. This is the same canker as Fig. 75, after treatment.

Mr. M. B. Wait, in a lecture at Lockport, N. Y., Jan. 3, 1906, before the New York State Fruit Growers' Association, recommended the spraying of pear trees early in the spring with the Lime-Sulphur wash as a means of covering up "hold over" cankers of the fire blight that had been overlooked in the "cutting out process." This treatment serves only to destroy any bacteria that may exude from trees already diseased, and thus prevent the cankers from serving as sources of infection. It will not protect healthy trees from infection. A similar treatment of cankered apple trees would certainly be of value.

8. DISTRIBUTION AND SEVERITY OF THE DISEASE.



FIG. 80.—Pruned stub canker that had spread down side of limb during early spring of second year. Diseased tissue cleaned away, treated with corrosive sublimate and painted. Good calluses formed. Canker ceased to spread.

Since the first specimen of blight canker was received from the Upper Hudson River region early in the summer of 1904, evidence has been constantly accumulating that points to a very wide distribution of the disease. Numerous trips during the last two seasons have convinced me of its very general occurrence throughout this State. Practically no orchard of any size visited has been without some trace of it.

Certain sections have suffered much more severely than the rest of the State. The accompanying map (Fig. 82) shows the regions known to be most seriously affected. No doubt other localities have suffered as severely as those indicated, but limited time and funds at our disposal for this work have made a more extensive survey impossible. A careful and systematic examination of the orchards in all of the apple-growing sections of the State is very desirable, not only that the exact extent and severity of this disease may be determined but also that a comparative study of the distribution of other canker diseases may be made.

As already pointed out, the disease has been epidemic only in a few rather well marked and restricted sections of the State. In the Hudson River Valley north of Albany the canker has destroyed nearly every young orchard. In the region about Schuylerville and Saratoga its ravages seem to have been most fatal. Throughout that section a number of orchards were set some ten to twelve years ago. These were just coming into bearing when the disease began to appear in alarming severity. At first only a few trees died here and there in an orchard, but by 1904 the loss had in many cases reached more than 50 per cent, and a careful examination of several

orchards showed that not less than 95 per cent of the trees were diseased. All along the line of the trolley north of Albany and about Saratoga, the dead and leafless branches of the young apple trees bear witness to the destructiveness of the malady. The severe winters of 1902-3 and 1903-4 no doubt

seriously affected the vitality of the trees, rendering them especially susceptible to attacks of the blight organism. The constant occurrence of the cankers indicate, however, that they were the chief factors in the death of the trees. No dead or dying trees in the young orchards, were found that did not show cankers. Moreover, trees were observed here and there that bore no trace of canker and were apparently healthy and vigorous but showed upon examination the blackened cambium region due to freezing. In one



FIG. 81.—Body canker cleaned out, treated, and painted about eight weeks after treatment. Good healthy calluses formed, which with proper care will completely heal this wound.

orchard of originally some 400 trees (Fig. 83) which began to go out in 1903, less than 50 were still alive in June, 1905, and but a very few of these were entirely free from the canker. The old orchards in this section have also suffered considerably from this same malady, and pear trees have almost entirely gone out.

In the region about Kirkville and Chittenango in the northern part of Onondaga and Madison Counties, a condition almost identical with that in the Hudson River region exists. The young orchards, while fewer in number, have suffered almost total destruction from this canker. The old trees in this section do not seem to have suffered to any considerable extent as yet. The disease appears to have become epidemic in this locality at about the same time as in the Hudson River region. In neither of these sections were

many active cankers observed in 1905. Practically all of them seem to have been formed during the seasons of 1902 and 1903. The summer of 1902 was a very rainy one in those regions, offering the very best of conditions for infection and development of the cankers. No doubt many of them appeared during that time but passed unnoticed by the ordinary grower until their baneful effects began to show in 1903. A few active cankers, however, were

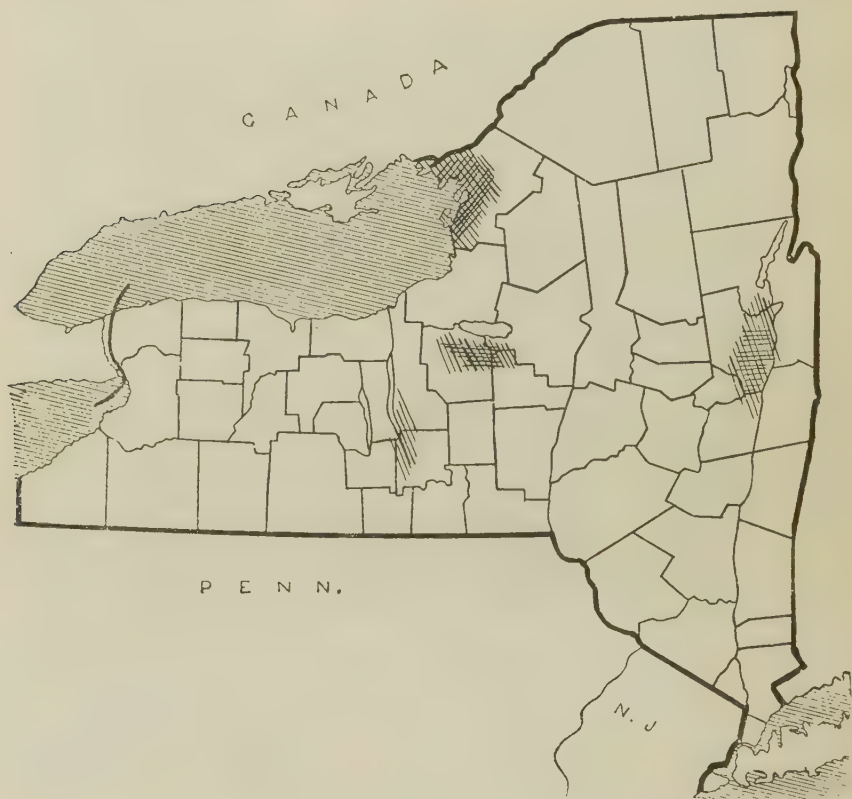


FIG. 82.—Map showing localities in the State where the disease is known to have been epidemic. The disease probably occurs throughout the orchards of the State, but is seldom severe.

noted on trees here and there in these badly diseased orchards. The force of the epidemic seems to have spent itself by the end of 1903, the completion of the destruction being effected by the rot fungi that had gained entrance to the heartwood through the canker wounds.

In Jefferson County along the eastern end of Lake Ontario, especially in the neighborhood of Chaumont, the disease had completely wiped out many of the young orchards even before 1903. Farmers in this district assured me

that their trees had been dying from this disease of trunks and limbs for several years. Their statements were borne out by the advanced stage of decay of most of the cankered trees. The disease was active in trees which had not yet succumbed, and reports from that section showed that it was still at work in 1905.

The three sections already described are, so far as I know, the only places in which loss from the canker has been severe. An examination of the young orchards about Ithaca show a large percentage of affected trees, but as yet the disease has not occasioned serious losses. In an orchard of about 350 trees which has been under observation throughout the past season, about 85 per cent of the trees show cankers, while the actual number of dead trees resulting from its attacks has not exceeded five per cent. It is, on the other hand,



FIG. 83.—Orchard of Mr. Henry Peck near Schuylerville, which originally contained some 400 trees. They began to go out in 1903 and in June, 1905, less than 50 trees were still alive. A very few of the fifty were entirely free from the canker.

a significant fact that a very large proportion of this five per cent has died during the past summer. Reports of what appear to be the same disease have come from other sections of the State.

The canker is not confined to this State alone. Reports and specimens from different places indicate that it is more or less common in New Jersey, Delaware, Kentucky, Kansas, Iowa and Wisconsin. What is doubtless the same disease is also reported from Canada. In fact, it is safe to say that wherever the "twig blight" form of the disease occurs, the *canker form* on limbs and body is more or less common. A study of horticultural and agricultural literature shows that the disease has been destructive not only in nearly every apple-growing region of the United States and Canada, but probably also in England,²¹ as well.

9. THE BLIGHT CANKER IN ITS RELATIONS TO WEATHER CONDITIONS.

It is well known that the "blight" in the twigs of pear and apple trees is most active and severe during a continued period of warm muggy weather. The same is to be said of the cankers on the limbs and bodies of the trees. Considering that both are due to the activity of the same organism, this is to be expected. It was repeatedly noticed during the past season that the active spread of the cankers was coincident with certain periods of rainy weather. The progress of the disease through the bark is always abruptly checked on the appearance of bright sunny days. The recurrence of favorable weather may often cause a renewal of activity, the canker spreading and increasing its former extent. This usually results in concentric cracks within the cankered area. (Fig. 53.) This relation between the activity of the canker and the condition of the weather seems to be dependent on two factors: (1) The increased moisture content of the soil results in an increased amount of water in the bark and growing tissue of the tree, which, in connection with high temperature, causes the rapid growth of succulent tissue. This condition of the host is the most favorable for the growth and rapid multiplication of the bacteria. (2) The atmospheric humidity itself seems in some way directly to affect the activity of the parasite; for, although a heavy rain followed by bright warm weather would seem to afford ideal conditions for the rapid growth of the tree, such weather was observed to be much less favorable to the activity of the cankers than damp cloudy days. Smith has observed⁸ in his work on the asparagus rust that atmospheric conditions, aside from their indirect effects through the host, exercise a direct influence on the formation of æcidiospores by the parasite. The spores were observed to form only during periods of abundant atmospheric moisture,—conditions most favorable to their germination. The effect of cloudy weather on the canker organism seems to be of a similar nature. The rapid growth and multiplication of the bacteria result in their exudation in large drops (Fig. 51) from the diseased tissue, from which, through the agency of insects, they are carried to other trees. Bright sunny weather would cause this viscid substance to dry and harden at once. But, as we have seen, the activity of the organism is checked by bright days, and consequently there is no exudation.

Humidity of the atmosphere is necessary not only for the best development of the bacteria, but is requisite also for the successful infection of healthy tissue by them. As has been stated before, infection can take place only through a wound of some sort. The moisture in the air prevents the rapid drying out of the infection court, thus affording the bacteria sufficient time, under favorable conditions, in which thoroughly to establish themselves. The bacteria are quickly killed by the drying out of the wound before they have infected the living tissue.

As a general conclusion, then, we may say that those weather conditions most favorable to the activity of the disease in the tissues of the host are also

the most favorable to the dissemination of the bacteria and the infection of healthy trees.

The disease generally manifests itself in the twigs only during the warmer seasons of the year. The cankers, although they grow most rapidly at this time, may be active at almost any season. I have observed them slowly extending along a limb during March and April (Fig. 76).

10. PROOFS OF THE BACTERIAL NATURE OF THE DISEASE.

I stated in the early parts of this bulletin that the cankers are caused directly by bacteria. It remains to indicate more in detail the proofs of this assertion. These are as follows:

1. *Presence of the bacteria in the cankers.*—These are always to be found in abundance in actively spreading cankers and in milky viscid drops which frequently exude from the diseased bark.

2. *Absence of fungi.*—Although diligent search with the microscope was made repeatedly, no trace of fungous mycelium was ever discovered in freshly cankered bark. The mycelium of common rot fungi is almost always to be found in the dry tissues of old cankers. In some cases, these saprophytic forms enter very soon after the bacteria have killed the bark.

3. *Production of cankers by inoculation.* (Figs. 65 and 66.)—Fortunately for my investigations, an active canker was discovered on an apple tree on the University grounds. Bacteria taken directly from this canker were introduced into the body of a healthy apple tree and also into that of a healthy pear tree. A sterile scalpel was used in making the incision into the bark, which had been washed with a solution of corrosive sublimate. A bit of the diseased tissue was carefully removed with a sterile scalpel and inserted into the wound, which was then sealed with grafting wax. A number of inoculations were made in each tree. Two typical cankers developed in each case. Those on the pear (Fig. 66) developed first and became more extensive. Those on the apple (Fig. 65) developed more slowly and never became so large. It was subsequently found that pure cultures of the organism could be regularly obtained by transferring with sterile scalpel bits of the diseased bark to potato bouillon. These inoculations may then be regarded as made from practically pure cultures. Two accidental inoculations (Figs. 77 and cover) of the bacteria into healthy trees and limbs also resulted in well developed cankers. To these I have already referred (p. 117).

4. *Production of twig blight with bacteria from canker* (Figs. 67 and 69).—At the same time that the inoculations into the bodies of the trees were made, bacteria from the same canker were introduced into blossoms and tips of growing twigs of both pears and apples. These were practically pure cultures, as a sterile needle was used to transfer the bacteria from the canker to the twigs and blossoms. Infection took place from nearly every inoculation, giving well developed cases of twig and blossom blight in 10 to 14 days (Fig. 68).

In the meantime, pure cultures were secured by dilution in agar plates and also by direct transfer from the diseased tissue of the canker into potato bouillon. A set of inoculations was now made from these pure cultures into twigs and green fruits of both pears and apples. These likewise resulted in nearly 100 per cent of infections.

5. *Observations on the formation of cankers.*—During the early part of July, twig blight became very common on the apple trees throughout the region about Ithaca. There was also a second severe attack of it during the latter part of the month and the early part of August. The blighting of watersprouts and short shoots on the bodies and main limbs of the trees resulted in the formation of many small cankers. Several of these I carefully observed and photographed at different stages in their development (Fig. 74). Pure cultures of the bacteria were also secured from these sources. There was absolutely no doubt as to the nature of the organism causing them.

11. THE IDENTITY OF THE CANKER ORGANISM WITH THAT OF THE FIRE BLIGHT OF PEARS.

During the epidemics of twig blight just referred to, many of the fruits of both pears and apples were observed to be affected with the disease. (Fig. 71.) They showed on the surface watery spots which gradually turned brownish and during cloudy days, drops of the viscous exudation appeared on the exterior. On cutting one of the fruits open the flesh was found to be tough and leathery with a milky sap collecting at the core. Gradually the flesh became brown and the fruit withered, finally turning black, especially in the case of the pear, drying up and falling to the ground.

Pure cultures were now secured from the following sources :

1. Active cankers on the limbs of apple trees (natural infection).
2. Blighted twigs of apple (natural infection).
3. Blighted twigs of pear (natural infection).
4. Blighted fruit of pear (natural infection).
5. Blighted fruit of apple (natural infection).
(Two cultures from widely separated localities.)
6. Blighted fruit of apple (artificially infected from canker on apple limb.)



FIG. 84.—*Bacteria directly from active canker on apple tree. Stained in carbol fuchsin. Showing various forms of the organism as they occur in the diseased bark.*

The pure cultures of bacteria from these different sources were each carried through 12 differentiating kinds of media (see page 131) and a careful record of growth, characters and reactions made. This comparative study showed the growth on a given medium to be the same for all the different cultures, thus establishing beyond a doubt the identity of the organisms causing the canker on the bodies and limbs of apple and pear trees and the fire- and twig-blight of these trees.

A third set of inoculations was made with the bacteria from certain of the above cultures. This was in August and the young shoots of the pear had ceased to grow. The fruits, however, were in just the right stage for infection. The shoots of the apple were still actively growing. Some 10-12 cross inoculations each were made as follows with the bacteria:

1. From canker to twigs of apples.
2. From canker to fruit of pears.
3. From twigs of pears to twigs of apples.

All gave nearly 100 per cent of infections:

12. NOTES ON THE MORPHOLOGY AND CULTURAL CHARACTERS OF THE ORGANISM, *BACILLUS AMYLORORUS* (BUR.) DETONI.

Morphology.—Direct from an active apple tree canker in hanging drop of sterile tap water. Short rods with rounded ends, single individuals nearly oval, 1.5-2 μ long a little more than half as thick, occurring singly, in pairs, fours or even more, end to end. Many but not all motile.

The organism was also examined (in hanging drop of beef bouillon) from cultures on the following media: beef bouillon, agar plate, agar slant, milk and potato plugs. All of these cultures were two days old except the agar plate and milk, which were several days older. The milk had thickened. The organisms varied little in these different media from the form and size observed in those direct from the diseased bark. They occurred singly or in pairs and frequently in short threads except on the potato plugs. There they were nearly all single. They were motile in all of the media examined but exceedingly so on potato plugs where they also appeared to be slightly larger.

Cultural characters.—Pure cultures obtained from the sources already detailed on page 130 were grown in the different media during July and August at ordinary room temperature. The media were all titrated to 1.5 acid unless otherwise noted. The work was done in the Bacteriological Laboratory of the State Veterinary College.

Gelatine plates.—Growth very slow, colonies becoming evident in about three to five days as tiny specks. Under the low power of the microscope they appear as small globose or lenticular growths, sharply outlined, yellowish. Surface colonies slowly liquifying the gelatin, forming little pits.

Agar plates.—Colonies evident by the second day, becoming characteristic by the fourth or fifth day. The surface colonies are then from two to three mm. in diameter in the form of a thin, white, finely granular or cloudy circular growth with a dense, sharply defined white center; margins even or slightly wavy. Deep colonies somewhat larger than the central mass of the surface colonies, globose or more often lens-shaped, dense opaque, yellowish. Under the microscope the central mass of the surface colonies and the entire deep colonies appear opaque, homogeneous and sharply defined, yellowish. The surface growth is coarsely granular or flocculent, whitish.

Potato Bouillon.—Becomes uniformly and moderately clouded in 24 hours. When shaken shows waves or clouds from the surface into the lower liquid, indicating that growth is most active at the surface; with slight sediment and flocci, the flocci are easily dissipated on shaking; slightly acid to litmus paper. After about 48 hours the liquid becomes uniformly and heavily clouded. Flocci more abundant and more or less persistent. Alkaline. After about 20 days the liquid becomes clear above with abundant sediment and flocci at the bottom and strongly alkaline. No odor ever developed.

Beef Bouillon.—Becomes faintly and uniformly clouded after 24 hours with flocci and sediment, slightly acid. After 48 hours cloudiness slightly increased. Flocci abundant and more or less persistent, neutral to litmus paper, becoming finally strongly alkaline and after 20 days showing tendency to clear. Odor not marked.

Sugar Free Bouillon.—Perfectly clear after 24 hours, the only evidence of growth being a slight sediment at the bottom. Neutral to litmus paper. After several days becoming faintly cloudy and alkaline. No indol produced.

Agar slant.—Growth in 24 hours, moderate, glistening white opalescent, thick but not spreading much, often in isolated circular colonies above, becoming more diffuse and spreading below toward the water at the base of the slant. Water of condensation turbid and with flocci. Growth not viscid. Increase of growth after this time very slight.

Gelatin Slab.—Growth slow and at first feeble. Beaded or granular along line of needle. Surface growth spreading with irregular or erose margin, which is thick and white, the center thin and granulose; liquifaction very slow, becoming evident only after several days, crateriform to stratiform.

Potato plugs.—Growth feeble becoming evident after a day or two as a thin moist pearly white coating over the surface of the potato, not viscid. No further change noted even after several days.

Glucose agar.—(Melted, inoculated, shaken and allowed to cool).—No gas. Growth in 24 hours vigorous forming a thick white layer at the top, below granular from the minute buried colonies. Little change later except in increased thickness of this white surface layer.

Milk.—No change until about the third or fourth day when it begins to thicken becoming very thick by the fifth or sixth day. The milk does not curdle but becomes subgelatinous. Finally after ten days or two weeks the thickened portion gradually settles leaving a clear watery liquid above. At first acid becoming strongly alkaline.

Litmus milk.—No change even after two weeks, never thickens.

Glucose bouillon.—Uniformly clouded at the end of 24 hours with abundant large flocci and frequently a weak pellicle. Little change in growth later. Remaining acid.

Lactose and saccharose bouillon.—No growth evident even after ten days.

Three descriptions of *Bacillus amylovorus* based on cultural characters

seem to have appeared thus far in literature. The first of these is a part of the classical work on pear blight done by Arthur¹ in 1886. He grew the bacteria in various kinds of broths or liquid media and to a limited extent on solid media. The next description to appear was one by Chester (1900) based upon the study of a single pure culture from a blighted pear twig. The organism was grown in but a relatively small number of kinds of media and the reactions recorded differ strikingly from those obtained by Jones² who published the third and most recent description (1902). The work of Jones was based upon a study of the organism from blighted twigs of both the pear and plum carried in parallel series through many kinds of media and extending over a period of eight months. Numerous successful inoculations were also made with bacteria from these cultures at different times throughout the period during which the cultures were under observation. My own cultural studies while not as extensive as those of Jones tally quite closely with the reactions which he obtained on similar media. It should be recalled in this connection that the bacteria which I had in culture were from the various forms of the disease on the apple tree as well as from the pear.

13. SECONDARY FACTORS IN THE DESTRUCTIVENESS OF THE DISEASE.

I have already made casual references to certain things and conditions that may strongly aggravate the effects of canker attacks. My own observations along this line, while of a very general nature, indicate that this phase of the subject is one of extreme importance; for upon these secondary factors may depend not only the very general appearance of the disease in a given locality but also the subsequent effects of the same.

Those agents which seem most frequently to aggravate canker attacks are; winter injury of the trees, cultivation, fertilizing, and attacks of secondary organisms like rot fungi, etc. The first three of these result in a predisposition of the host to attacks of the bacteria, while the fourth, by taking advantage of the wounds made by the canker, may complete the destruction already begun. A summary of my observations on each of these factors follows:

Winter injury.—Anything that reduces the general vitality of the tree tends to render it more susceptible to attacks of the bacteria. I have already referred to the apparent effects of low temperature in relation to this disease in the Hudson River region. A long growing season during 1902, with excessive rains followed by a sudden and extreme fall of temperature early in December, is referred to by growers in that section as the beginning of the injury to their orchards. The winter that followed was a severe one with sudden and severe changes of temperature during the early days of the spring of 1903. Many trees failed to leaf out and large cankers were now observed on limbs and bodies of dead and dying trees. The general conclusion at once prevailed that these dead spots were the direct results of these weather conditions. Careful questioning, however, brought out the fact that previous to 1902 cer-

tain growers had observed these cankers on the bodies of their trees and some few trees had died, apparently from these injuries of the bark. It is also pertinent to point out at this place, that the rainy weather of 1902, which resulted in an excessive and long continued growth of tender tissues, afforded conditions most favorable to the infestation and development of the canker bacteria. It seems very reasonable to suppose that many of the cankers appeared during the summer and autumn of that year. That they were not generally observed by the grower until 1903 is probably explained by the fact that the effects of their attack did not become evident in the foliage of the trees until that season. My own observations on cankers with whose entire development from the beginning I have been acquainted, show that rarely do they cause the death of the affected limb or tree the first season. More than that, no evidence of their presence is to be detected in the appearance of the foliage. I am, therefore, of the opinion that many of the trees in the Hudson River valley and about Kirkville were cankered prior to the winter of 1902-3. The severe weather no doubt weakened the trees yet free from the disease, thus rendering them more susceptible to attack during the summer of 1903. It also further weakened the trees already affected, rendering their destruction from further growth of the cankers certain. The appearance of a large number of the cankers in 1904 showed clearly that they had originated in 1903; others gave evidence that they had originated prior to that time (Fig. 54). The winter of 1903-4 was also a severe one and no doubt added to the sum of the injury already produced. To just what extent the winter injury in this section is responsible for the death of the trees is a question. In certain cases it was very evident that the tree had died from this cause. Such injuries were easily distinguished, however, from canker spots. That these dead spots on limbs and body and in the crotches resulted from freezing is, to say the least, exceedingly improbable. I base my opinion on the following facts:

- (1) The cankers may appear on any side of the body or main limbs;
- (2) The spots are usually more or less circular or oval with sharply defined margins;
- (3) The cankers are in practically every case formed about the base of a shoot or about a wound of some sort;
- (4) Every individual canker whose entire history is known was observed first to appear during the warm weather of spring or summer;
- (5) Typical cankers have been observed to form about the base of young sprouts which have been twig blighted;
- (6) Typical crotch cankers appeared during the past summer in trees which throughout the spring and early summer appeared to be perfectly healthy;
- (7) The bacteria of pear blight have been found repeatedly in the tissue of actively spreading cankers;
- (8) Spots, to every appearance exactly like typical cankers, were produced in the bark of healthy trees by inoculation with blight bacteria.

Cultivation.—It is known that well cultivated pear trees suffer more severely from "fire blight" than do those not so treated. Constant cultivation results in rapid growth and consequently succulent tissues, which are most

favorable for the development of the blight bacteria. My observations seem to show that the same thing is true as regards the canker form of the disease in the apple tree. A number of young orchards were visited that had received little or no cultivation since setting and had consequently made a much slower growth than cultivated ones of the same age. They were, however, remarkably free from cankers, although not entirely so. In one orchard visited, it was noticed that three or four rows of trees at one end were practically free from the disease while the remainder had nearly all died from its effects. Inquiry brought out the fact that these few rows had received but little cultivation while the remainder of the orchard had had the best of care in this respect.

Fertilizing.—The abundant application of nitrogenous manures also results in rapid and excessive growth. The tissue does not ripen promptly and so affords conditions favorable to the blight. Certain growers say that they can prevent the ravages of blight by the use of phosphates, either bone meal or some form of phosphoric acid and potash. They do not use stable manure. They point out that the phosphates cause the new growths to ripen quickly.

Rot fungi.—In the first part of this bulletin, I have pointed out that the wounds resulting from the formation of the cankers afford infection courts for the entrance of decay-inducing fungi. The dead bark affords a most suitable food supply on which the fungus can feed in the first stages of its germination and growth. It serves, moreover, as a sponge in the retention of the moisture necessary for the further development of the fungus and its entrance into the wood of the tree. If the canker has been formed about the base of a blighted watersprout, the dead tissue of the shoot affords a direct entrance for the decay fungus to the heart wood of the tree. Once in the heart wood, the mycelium spreads rapidly through the lifeless tissue, causing it to rot. It also frequently attacks the living sap wood and destroys it also, so that the tree is ruined or even killed outright. The crotches of trees where attacked by the canker serve admirably for the entrance of these rot organisms. The cankers formed about pruned stubs also act as infection courts: first, by preventing the prompt and rapid healing of the exposed cut surface; and second, by affording in the dead tissue of the cankered collar, food and moisture for the saprophytic forms. Almost invariably on removing the cankered bark from these stubs, it was found to cover a white web of mycelium which surrounded and penetrated the dead stub. The heart wood of these diseased stubs had frequently reached that stage of decay that it was soft and watery and was easily removed with a knife blade for a long distance down into the limb. In the Hudson River valley, diseased trees were frequently so heart-rotten that limbs apparently healthy were easily snapped in two, showing only a very thin outer shell of healthy sap-wood and bark.

This matter of the decay fungi that follow the canker is of very considerable importance and a factor to be reckoned with in any method of treating the cankered trees. Their relatively early appearance in cankered areas

makes it imperative that to secure immunity from their attacks the diseased tissue must be removed as soon as discovered and the wound properly treated and painted over.

An examination of a number of old cankers will show a large variety of forms of these saprophytes. Many common species of the imperfect as well as ascomycetous fungi will be found. I have also observed various species of the basidiomycetes fruiting in these dead areas.

14. RESISTANT AND SUSCEPTIBLE VARIETIES.

Early in the investigations it was observed that certain varieties are more susceptible to attacks of the canker than others. Fortunately, in the orchards examined there was in each case a number of varieties represented so that considerable data as to relative resistance was secured.

Only one variety so far has been observed that seems to be entirely immune to canker attacks. In an orchard of some 200 trees in the worst infected section of the Hudson River region, all the trees had gone out but seven. These were Wolf River. They showed not a single canker and were strong and thrifty. A single tree of this same variety was also observed in another orchard in the same locality. It, too, was entirely free from the disease. The Wolf River is not regarded as a desirable fruit but could be used to advantage as stock for top-grafting. By setting desirable varieties well out on the main limb the chief source of trouble would be removed. Talman Sweet, although not entirely immune, appears to be fairly resistant and as stock for top grafting seems to be valuable.

A provisional arrangement of varieties so far observed in the order of their resistance may be said to be; Wolf River, Talman Sweet, Pewaukee, Red Astrachan, Tetofsky, Grimes Golden, Wine Sap, Fameuse.

In most of the affected orchards the Baldwin was the first to go out from canker attacks. The Ben Davis seems to be almost as subject to the disease as the Baldwin. The susceptibility of this variety to the so-called "sun scald" has been reported by growers in the Mississippi Valley³. The more susceptible varieties seem to be; Baldwin, Ben Davis, Mann, Hubbardston, Fall Pippin, Stark, Greening.

In general, summer and fall varieties seem to be less liable to attacks of the disease, or at least suffer less, while winter varieties are apparently more susceptible. It may be mentioned here that the writer has observed this same peculiarity in the attacks of the apple rust, the roestelia stage of *Gymnosporangium macropus*.

The study of varietal resistance has not been extensive and the above lists are to be regarded as entirely provisional. Further observation along this line will no doubt very materially change the number and arrangement of varieties. Enough has been observed, however, to indicate that it offers valuable suggestions to growers in regions known to be especially subject to canker epidemics.

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